is centered between 17.7 mm long header and footer sections) is machined a fin-containing microchannel. The adjacent SMR plate sections each have formed therein a header or footer channel of 2.03 by 0.66 mm cross section and 12.6 mm in length. The combustion plate is machined on the face adjacent to the web plate to form a 1.78 inch (4.52 cm) long combustion channel, to provide heat to the endothermic SMR reaction. The combustion channel has a cross section of 0.080 by 0.036 inch (2.03 by 0.91 mm). The combustion plate also contains jet orifices centered on the combustion channel centerline along the direction of flow, machined by electrode discharge machining (EDM) through a 0.150 inch (3.81 mm) plate thickness, thereby connecting the air header channel to the combustion channel. Combustion flows are fed co-flow with respect to the SMR gases. The combustion channel is fed hydrogen at the inlet to the combustion channel and pre-heated air is introduced the aforementioned airjet orifices distributed over the 45.2 cm length of the combustion zone, specifically at 1.0, 2.7.4.8, 7.4, 14.7, 24.4, and 34.0 mm downstream from the combustion zone inlet. The cross section of the airjet orifice at 1.0 mm and 4.8 mm axial location are oblong along the axis of flow with dimensions of 0.024 by 0.012 inch (0.61 by 0.30 mm) with full rounds at both ends. The cross section of the jet hole at 2.7 mm axial location is an equilateral triangle which "points" downstream, having sides of 0.024 inch (0.61 mm) and 0.05 mm radius rounds on the corners. All other air jet orifices are circular in cross section, with a diameter of 0.012 inch (0.30 mm). The hydrogen fuel is brought to the combustion zone in a 23.4 mm long header region with a 2.03 by 0.41 mm cross section. At the end of the combustion fuel header the 0.41 mm dimension opens up to 0.91 mm in a sudden expansion away from the web and toward the jet holes. Separating the combustion channel and SMR reaction process microchannel is a 0.060 inch (1.52 mm) web, solid except for the 0.023 inch (0.58 mm) diameter thermowells which are drilled 0.25 inch (6.35 mm) deep from the perimeter to the center of the web plate (which is also the center of the microchannel width). These thermowells, placed in the web at six locations along the length of the reaction zone, allow temperature measurement in the metal between the SMR and combustion channels via 0.50 mm type K ungrounded Inconel sheathed thermocouples without compromising the gas-tight seal on either the combustion or SMR channels. Gases are introduced into the air, hydrogen, and SMR reactant inlets and removed from the combustion exhaust and SMR product outlets via 1.75 mm inside diameter (3.18 mm OD) tubes which extend orthogonal to the plane of each plates. An additional four 1.75 mm ID tubes provided access to the SMR channel at both ends of the fin and to the combustion channel at levels corresponding to the beginning and end of the combustion zone.

[0106] The FeCrAlY fin inserted into the microchannel is 1.78 inches (4.52 cm) in length and 0.100 inch or 2.54 mm wide at the base. The base has a height of 0.006 inch or 0.152 mm. Each fin is 0.014 inch tall and sits on top of the 0.006 inch base. Each fin is spaced 0.010 inch apart from the adjacent fin to create a gap for flow of 0.010 inches. There are 4 fins protruding up from the fin support. The fin support sits on top of the heat transfer plane that separates the SMR reaction process microchannel and the adjacent heat exchange combustion reaction chamber.

[0107] The cross-section of the microchannel containing the fin insert is 0.080 inch (2.03 mm) (extending to 0.100 inch (2.54 mm) at the fin base) by 0.026 inch (0.66 mm). The microchannel reactor fin has a length of 1.78 inches (4.52 cm) containing an SMR catalyst washcoated on a FeCrAlY fin insert. The fin is inserted into the microchannel reactor before welding the reactor, along with two small Inconel pieces (0.18 by 2.54 by 5.74 mm) at either end of the fin which hold it centered lengthwise in the channel and prevent flow in the plane of the fin base immediately upstream and downsteam of the fin.

[0108] Before inserting the FeCrAlY fin into the process microchannel, the fin is cleaned using 2-propanol, HNO_3 (20 wt %), and deionized water by ultrasonic cleaner 10 min each. Then, it is heat treated in air at 1000° C. for 8 hrs with a heating and cooling rate of 3.5° C./min before placing into the process microchannel and welding the device at the perimeter.

[0109] Before coating the FeCrAlY fin with catalyst, an oxide layer is grown on the FeCrAlY fin by flowing 200 standard cubic centimeters (sccm) nitrogen through each of the inlet tubes (air, fuel, SMR reactant) while heating to 1000° C. at 3.5° C. per minute. The nitrogen flow is then stopped and 200 sccm of hydrocarbon free air is fed through the three inlets for 24 hours at 1000° C. The device is then cooled to 25° C. at a rate of 3.5° C. per minute (maintaining continuous air flow), and placed in the process microchannel. The device is welded at the perimeter.

[0110] Using external washcoat holes, the SMR and combustion reactant channels are wash-coated with stabilizer and active metal only in the regions corresponding to the SMR finned substrate. An alumina sol coating is applied to the entire reactor, including inlet and outlet tubing, to help prevent background activity.

[0111] Alumina sol (14N4-25 supplied by Sasol) is introduced to the combustion and SMR channels using a syringe to fill the channels and inlet/outlet tubing from the bottom with the channels oriented vertically. The device is allowed to soak for 2 minutes before the sol is removed from the channels. Nitrogen is fed at 5 standard liters per minute (SLPM, standard defined as 0° C. and 1 atmosphere) to remove excess sol. The device is dried in a furnace at 100° C. for 1 hour with hydrocarbon free air flowing at 150 cc/min followed by calcination at 450° C. for 4 hours at a heating and cooling rate of 10° C./min. A second layer of sol is then applied to the combustion and SMR channels in the same method described for the first layer of sol coating. A 10% by weight aqueous solution of $La(NO_3)_3.6H_2O$ is introduced continuously to the combustion channel using a syringe pump at a rate of 60 ml/hr. For this step and subsequent steps, the solution is continuously introduced through a washcoat tube at one end of the reaction zone and removed through a washcoat tube at the other end of the process zone with the channels in a horizontal orientation. During this coating step 20 sccm nitrogen are introduced through the inlet and outlet tubing to prevent impregnation of the inlet and outlet regions. Afterward the solution is removed from the channel and the device is flushed with nitrogen to remove excess solution. The same procedure is repeated to coat the SMR channel with the aqueous solution o $La(NO_3)_3.6H_2O$. After the SMR channel is flushed with nitrogen, it is dried at **100**° C. for 1 hour in hydrocarbon free air at 150 cc/min. Then it is calcined at 1000° C. for 4 hours with a heating and cooling rate of 3.5° C./min.